RELIABILITY FOCUSED MAINTENANCE SYSTEM—A CASE STUDY

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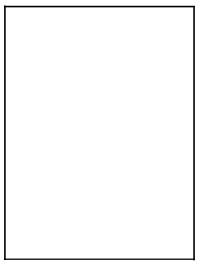

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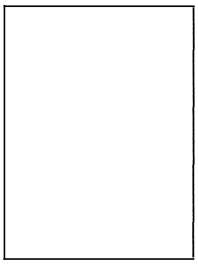

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ABSTRACT

A case study of how a large organization is utilizing the combined strengths of commercial off-the-shelf software packages to implement a corporate-wide reliability focused maintenance initiative is presented. The integrated package meets the needs of information systems staff and is most valuable in implementing the work process and cultural changes needed to meet the company's goal of incident free operations. A new work maintenance system allows users to more easily record extensive maintenance and repair data. A powerful centralized equipment database pulls together information from many different systems and makes it available to everyone participating in the program. A new reliability software system makes use of real-time data gathered through the work management system and uses them to perform analysis, trending, and reporting. Alone, each system is a powerful tool. Used together, the analysis tools of the reliability system work hand in hand with the tracking features of the work management system, allowing each to function at its maximum potential and provide true bottom line savings.

INTRODUCTION

As the beginning of a new millennium approaches, businesses are finding that they have to do more than work harder to stay competitive in an ever-changing world market. The bottom line now includes not only profit margin, but also cost management, environmental concerns, best practices, safety of employees, and public image. New technology has significantly improved the bottom line—better equipment, better training, better monitoring, and more automation. Over time, however, it has become apparent to many industry leaders that the savings and competitive edge gained through these means is beginning to plateau. As a result, many are looking at ways to make the equipment and processes that they have already implemented work better and more efficiently. One of the ways to achieve this goal is to increase the *reliability* and *availability* of existing equipment.

Chevron Corporation, hereafter referred to as the company, was one such company looking to make its equipment and processes work better, not just harder. This company is the fifth largest oil company in the world and is involved in all aspects of the petroleum industry. They established as a primary initiative the goal of incident free operation. Incidents are an important component in the profitability picture of the refining organization and a significant public relations problem. This company has traditionally tracked incidents in terms of both actual costs and the lost profit opportunity of the incident. The incident free operation initiative involved shifting the emphasis of their maintenance efforts from fixing problems to preventing problems from occurring in the first place. They determined that the way to achieve this goal was to combine the efforts of the maintenance and reliability teams. The effort resulted in a leading edge philosophy known as the reliability focused maintenance system (RFMS).

Implementing RFMS proved to be a challenge. As part of the effort, the company decided on an innovative approach that not only takes advantage of the latest state-of-the-art computer technology, but also allowed them to rethink their entire approach to maintenance and reliability. The company chose to interface stand alone third party software applications into one integrated system that takes advantage of the strength of the combined applications. Meridium Industrial Applications Suite, hereafter referred to as the reliability system, is an industrial software package that includes powerful reliability analysis tools, an instrumentation package, and a condition monitoring module. In

addition, included in the Meridium suite of products are tools for configuring a flexible, powerful equipment database, hereafter known as the equipment database. Indus PassPort, hereafter referred to as the work management system, is an industrial software package designed to handle work management, labor entry and reporting, requisitioning, document management, and action tracking. In addition, an interface is also being created to SAP Materials and Financials software, hereafter referred to as the financial system.

INTEGRATED SYSTEM APPROACH

The company assigned senior management to study outside organizations and industries to determine mechanisms for improving performance and achieving incident free operations. RFMS was adopted and assigned the mission of institutionalizing the reliability focused maintenance philosophy using the following strategy:

- Ensure that accountability for equipment reliability is shared between the operations, technical, and reliability/maintenance organizations.
- Encourage and accelerate the current direction to move from individual maintenance organizations to reliability focused maintenance organizations, all functioning on the same principles.
- Develop new management metrics that recognize and reward for equipment reliability, thereby reducing management focus on performance measurements such as $/barrel and the Solomon metrics.

In pursuing the incident free operation initiative, the maintenance "best practices" team searched for a work management system that they could use across all sites. Independently, the reliability team was also looking for a new state-of-the-art reliability system. RFMS combined the maintenance effort with the reliability effort to produce a common goal of increasing the reliability of equipment and practices. Working together, the two groups considered many existing factors before making the decision to combine their needs and implement an integrated system. These factors included current maintenance costs and production issues, environmental issues, the existing system, and the existing culture.

Current Maintenance Costs and Production Issues

It was determined that maintenance costs were not competitive. Failures resulting in downtimes had cost the company money in the areas of energy costs, wear and tear on other equipment, equipment failures associated with bringing equipment back on line after a downtime, etc. Support costs for maintaining multiple equipment and maintenance databases were high. Unplanned repairs, plant slowdowns and shutdowns, and inability to extend best practices company-wide across all sites resulted in additional overtime, maintenance costs, and increased incident costs.

In terms of production issues, the problems were more day-to-day. Mechanics would arrive at a location to do a job and equipment was not ready or parts were not available. Scheduling between maintenance and reliability groups was not easy and "worst actor" repairs were not always coordinated with reliability. All of the incidents that can occur—fires, spills, unplanned emissions releases, etc.—when corrosive chemicals and flammable elements are subject to extreme pressure and heat were occurring on an all too frequent basis.

Environmental Issues

The company's corporate mission states that "We are committed to protecting the safety and health of people and the environment." Safety issues include safety for the men and women operating the equipment, those living in surrounding communities, and the environment as a whole. The company realized that each incident, no matter how small, increased the danger to the operator or mechanic. Each environmental issue or violation resulted in stricter and more costly standards being implemented, not to mention the cost in terms of strained public relations.

As ever stricter environmental standards were being put into place, the choice was to increase investments in equipment, monitoring devices, and personnel, or use reliability and availability to improve the resources that already existed. Improved reliability that helped to avoid even one environmental disaster was valuable. Improved availability and reliability would help to prevent small violations of environmental standards that added up, nickel and dime, to tremendous cost savings. The most cost effective way to deal with environmental issues was to meet increased process requirements and environmental requirements without huge investments in additional hardware.

Existing System

On the maintenance side, each of the company's six USA domestic sites had their own computer maintenance management system (CMMS) and each system used multiple databases for tracking the various aspects of the process—equipment, work orders, inspections, results, etc. The sites had traditionally been run as separate profit centers with little cooperation and standardization between facilities.

On the reliability side, a reliability organization had been in place for 20 years. This group documented equipment history and maintained the metrics of equipment reliability with a primary focus on rotating equipment. The legacy system that supported the reliability effort was a 20 year old mainframe system designed for use with machinery, combined with mainframe financial and materials management systems, and a variety of manual and desktop applications that stored equipment lists, technical data, work management, and safety and compliance information. State-of-the-art at one time, the mainframe technology and software could not compete with the power and performance of current PC-based systems, servers, and database applications.

Existing Culture

As a result of RFMS, the maintenance and reliability staffs, who were used to working independently of each other and focusing on their own goals, had to join forces to achieve the common goal of increased reliability. To make this effort successful, implementers had to overcome the existing culture. The feeling among many mechanics and operators was that an improved reliability system would mean less repairs, which meant less work and fewer jobs. They were also leery of a new computer system that they would have to learn, but might prove to be just another useless tool, resulting in less time to do the actual repairs for which they were responsible.

Many maintenance people were already doing a form of reliability—they knew when the equipment needed to be serviced to avoid problems. The goal of the integrated RFMS system was to pull all of this divergent knowledge together into one place, so that everyone could benefit from it.

SELECTING THE SYSTEMS

The project goal was to leverage and support ongoing IT initiatives toward RFMS in the following areas:

- Supply the tools (hardware and software)
- Provide the funding
- Lend leadership to establish an environment that would support RFMS

The business case for the project was based on the cost savings anticipated by the incident free operations initiative. A core project team representing the technical and business aspects of the project was formed to direct and guide the project through to completion.

Systems Considered

First and foremost, the core team recognized that they needed a system that was flexible and powerful enough to meet their needs. They had spent a great deal of time developing their work processes best practices and wanted a system that could be adapted to these requirements rather than forcing them to change their practices to meet the requirement of the system. In addition, they wanted a system that would support the often divergent needs of end users, management, and information technologists. The core team felt that the end-user interface should be intuitive and should ensure that the proper data were quickly available to the decision makers, regardless of the system being used. This meant that an integrated system was vital to the success of the project.

The maintenance team needed a CMMS system that would be responsible for work management. The reliability team needed an application that was capable of providing powerful reliability analysis and reporting functions. Both teams also recognized the need for a centralized, accurate, and powerful equipment database that could process and store millions of records quickly and efficiently. In addition, this database had to be flexible enough to capture and store data currently located in many different systems. Many of the primary benefits of the RFMS effort would come from the fact that the project promoted the sharing of best practices between the maintenance and reliability groups. The use of one tool across all sites also encouraged the sharing of best practices between sites.

And the Winners Are...

It quickly became obvious that no one system was going to meet all of the company's RFMS requirements. The solution appeared to be an integrated system with a seamless interface that would capitalize on the strengths of the selected reliability system and work management system and would also provide a powerful centralized equipment database. Equipment history and cost data gathered by the work management system could then be effectively used by the reliability system to help pinpoint and resolve problems with critical equipment. This, in turn, would help prevent incidents and create a safer working environment, and also a lower overall operating expense.

The reliability system chosen offered many benefits:

- Equipment registry
- Technical data
- Reliability analysis
- Reporting
- Condition monitoring
- Inspection and PM scheduling based on analysis
- Equipment inspection
- Instrumentation tracking

The work management system selected also had many needed features:

- Work management
- Preventive maintenance
- Equipment parts lists
- Requisitioning
- Labor entry and reporting
- Contracts management
- Management of change
- Document management
- Qualifications tracking
- Fugitive emissions tracking

The equipment registry function of the reliability system provided a powerful equipment database that could be interfaced with the work management system, so both could make use of the same information.

IMPLEMENTING THE SOLUTION

Implementation of a reliability focused maintenance system involved a radical change in the company's way of doing business, by forcing people to work together to develop company-wide best practices. In addition, divergent groups had to agree on a common platform, common terms, and common work practices.

Implementation

Implementation was a multistep process that included project organization, technical issues, business issues, integration, conversions, education, and system support.

- *Project Organization*—The RFM team established and funded the RFMS team to support the implementation of both the reliability and work management systems. The team members worked closely together, keeping in touch through weekly scheduled conference calls and face to face meetings every six weeks. As with any major business change initiative, the key to a successful implementation was the level of participation and support from the senior management in the organization. The RFMS Steering Committee was established to oversee the project and ensure senior management engagement.

- *Business Process*—Sub teams were created to focus on the specific requirements of each work process. Areas of interest included equipment and technical data for fixed, rotating, and instrumentation routine work, shutdown work, planning and scheduling, preventive maintenance, labor entry, contracts management, reliability analysis and reporting, inspection tracking, including scheduling based on reliability analysis, condition-based monitoring, and instrumentation. The teams were responsible for obtaining consensus on best practice and deploying the best practice across the system.

- *Integration*—The RFMS system required the integration of three commercial off-the-shelf (COTS) systems: the reliability system, the work maintenance system, and the financial system (see *Future Interfaces* later for more information on the integration with the financial system). The interface between the reliability system and the work management system had the following primary interface needs:

  - Import of equipment data from the reliability system (i.e., the equipment database)
  - Export of work order and equipment history to the reliability system
  - Export of actual cost data to the reliability system

- *Conversion*—A data conversion contractor was retained to support the data conversion efforts. The major areas of conversion included:

  - Equipment lists
  - Equipment technical data
  - Equipment parts lists
  - Preventive maintenance programs
  - Equipment history (20 years)
  - Equipment costs histories (20 years)
  - Personnel data
  - Training records
  - Emissions data

- *Technical*—A server was selected that would provide the needed architecture and room for growth. The IT department was

committed to a commonality of information systems enterprisewide, so it was necessary to choose hardware that could handle varied and heavy use. Several servers were installed, with each performing a specific function within the overall IT plan for implementing RFMS.

- *Education*—Vendors offered extensive training and produced training materials in conjunction with the core team. Core team members provided "train the trainer" education, enabling representatives to return to their individual sites and train others to use the system.
- *System Support*—Ongoing system support includes system administration, help desk, reports development, and desktop and infrastructure support at each site. The corporate IT organization is responsible for server support, integration development, and configuration management.

Integrating the Two Systems

The goal of the integration effort was to create an interface between two separate, stand alone database software applications—the work management system and the reliability system. In addition, both needed access to the central equipment database. Tying the two systems together was vital, because each complemented the other and made the entire program stronger by pulling together not only the data stored by both, but the people involved in both. This created a new tool with a common language for mechanics, operators, and engineers, and directly responded to the strategy of the RFMS initiative.

In integrating the systems, the core team had to determine the areas of overlap between the systems, then decide which was better suited as the owner of each process. Once this was decided, the core team looked at the areas wherein the two systems could work together and set about designing the interfaces needed to facilitate this sharing of data. Obvious areas where data could be shared included general equipment data, work order data, and cost data.

The People

The core implementation team included technical personnel and representatives from operations, reliability, and maintenance. Also included on the core project team were consultants from the reliability system and work maintenance system vendors. In addition, the team included representatives from each of the six USA sites.

Strong management of the process, both by the company and the software vendors, allowed for rapid implementation of the new combined system and quick turnaround in training, user buy-in, and bottom line results. Throughout the process, the role of IT team members was extensive in the areas of maintaining the database(s), installing the applications, maintaining the interfaces through batch processing, acting as liaison to technical representatives for the reliability system and work management system vendors, maintaining security over the entire system, and making recommendations to the core team as to hardware and configuration needs.

The Structure

The system utilizes a network of personal computers and servers. The interface supports real-time, unidirectional updates of equipment information to the work management system. It also passes work order data, associated to the proper equipment or location, from the work management system back to the reliability system for analysis. Datasheets in the equipment database are used to hold the shared work management data, and also reliability data collected directly for use by the reliability system. Records that are exchanged between the two systems are validated based on user-defined criteria. Errors occurring during the interface are detailed for quick debugging by system administrators.

User-defined flags can be placed on records for specific pieces of equipment to indicate that data are to be used in reliability analysis. This helps to filter the mass of data coming into the database and provide true analysis of only the most critical equipment. Flags can easily be updated to meet current business needs or expanded analysis capabilities. The hierarchy structure allows work orders to be broken into tasks, with each task defined as a child of the work order as a whole. This structure keeps all of the parts of a work order together and facilitates the tracking and scheduling of each individual task, based on the overall scope of the work order. Costs can be tracked for each individual task and summed for both the specific tasks and the entire work order. These data can then be used in reliability trending.

From a configuration standpoint, the flexibility of the two systems allows for easier integration, because both can be configured to support the other and the project as a whole. Equipment, location, and event records can be grouped into categories and hierarchies created to organize the databases. Datasheets are designed to track data for each group of records. The use of datasheets allows for a great deal of flexibility, as their content is completely user-definable. In addition, by settling on specific common datasheet designs, both maintenance and reliability staffs are assured that the data they need to do their job are collected and stored in a central location that is easily accessed by all who need this information. The development of a database structure and datasheets drove the creation of a set of common definitions, codes, and processes acceptable to both the maintenance and reliability people. In defining incidents such as failures, the company produced a means of using reliability practices to reduce those incidents.

User Involvement

By pulling in representatives from each site and both disciplines (reliability and maintenance), the project broke down traditional barriers between the two camps. The success of the project required that it be end-user driven. Without buy-in from the operators and mechanics on the floor, the system would not be used and cost savings would never be realized.

As part of the process to get users involved, extensive training was performed. The core team and training teams brought many operators and mechanics up to speed, despite the fact that most had never used a personal computer. Although many were skeptical at first, most found that the system was intuitive and easy to learn. They also quickly discovered that it allowed them to take a more active role in improving overall reliability and, in turn, increase profitability.

Buy-in took some time—users had to see that the system would really help them in their day-to-day work and was not just another useless tool. They had to see that the new system empowered them to work more independently and gave them the tools they needed to make many decisions on their own, rather than always having to wait for a supervisor to give them a new task.

Future Interfaces

The core team knew that other interfaces also needed to be considered as they planned the implementation of RFMS. They would need to be able to interface with other applications also being implemented by the company, either actively or in the planning stages. For example, the combined RFMS system would have to interface with the new financial system in the areas of material cataloging and cost tracking. The following are features of the integration between the work management and financial systems:

- Import of materials catalogs and on hand inventory data to the work management system from the financial system
- Import of project data to the work management system from the financial system
- Export of work order data from the work management system to the financial system

- Export of materials requisitions from the work management system to the financial system
- Import of material management activity to the work management system from the financial system
- Import of actual cost data to the work management system from the financial system

THE RESULTS

Currently, RFMS is implemented in all six USA domestic sites and integration is in place. Work continues on the cleanup and input of data, and further improvements are being made to the breadth and depth of the implementations.

The company is already reaping the results of its efforts through savings from the work management system and reliability systems as stand alone products. In addition, considerable benefits are already being reaped from the integration of the two systems and the resulting reliability focused maintenance mentality that they promote.

Savings from the Work Management System

The ability to write work requests directly to the system has dramatically altered the work practices of the mechanics and operators. Requests automatically go to maintenance supervisors for approval. Parts are ordered and are available when the mechanic arrives to do the repair. Work is scheduled and planned in advance so that it is done in a timely manner with all of the needed materials on hand.

The new system tracks maintenance and materials costs and equipment histories and stores them in a centralized database. Documentation included by each mechanic or operator is stored with the equipment and is available to anyone else who works on that equipment in the future. Best practices are recorded and shared across all sites.

Savings from the Reliability System

The new reliability system provides advanced data analysis using a battery of statistical tools. It takes cost and history data from the central equipment database and uses them to help identify and resolve problems with critical equipment. Improved equipment reliability and availability helps prevent incidents, creating a safer working environment and lowering bottom line costs, and making the work management system more effective.

The system tracks "worst actors," so that when repairs are done on this type of equipment, maintenance can schedule for a reliability analyst or engineer to be present. Rather than waiting for equipment to fail and then fixing it, the reliability system helps flag equipment that may need repair, based on analysis of performance, history, time in production, and performance of other equipment related to the equipment in question.

Savings from the Integrated System

An immediate benefit realized through the integrated system is the ability to schedule needed work ahead of time, rather than just dealing with problems as they occur. This means that the people, equipment, and tools needed to perform the work are available. The right procedures and the right tools make for a safer operating environment for everyone involved and across all facilities. By exchanging the "John Wayne" mentality of charging out and fixing the latest emergency situation, mechanics can systematically make repairs before critical mass is reached, thus improving the work atmosphere, profitability, and empowering employees by giving them more control over their own area of responsibility. As a result, repair backlogs are decreasing and focus can now be turned toward reliability and preventive maintenance—the source of the greatest future cost savings by reducing routine maintenance and the number and cost of incidents.

By interfacing the work management system to the equipment database and reliability system, data are captured and dumped into a centralized warehouse. This means that data located in multiple systems can be combined, compared, analyzed, and used. The equipment database has the flexibility to record various forms of data that might not fit into other systems, such as vibration readings from online vibration systems, process variables from DCS systems, and TML readings for corrosion analysis. Equipment history and cost data gathered by the work management system are effectively used by the reliability system to help pinpoint and resolve problems with critical equipment. This, in turn, helps prevent incidents and creates a safer working environment and a lower overall operating expense. Once the information is in the database, it can easily be used over time for reliability metrics trending by the reliability system. These metrics, based on actual data, can be used with confidence to make cost effective, long term decisions on maintenance issues.

Using reliability in conjunction with maintenance allows analysts to predict failures and perform maintenance before failures occur. Data analysis also reduces the amount of unnecessary preventive maintenance being performed based on design specifications or standard practice, rather than the actual number of failures and types of repairs historically performed on the equipment in question. The results of a detailed reliability analysis may be the driver for a change in the maintenance or inspection schedule, due to a requirement that some type of corrective action be taken. A seamless interface between the reliability system and the work management system takes the results of the reliability analysis and makes it the impetus for scheduling and performing equipment inspection, maintenance, and repairs.

By integrating the reliability and work management system, the company got the best of both worlds, because the analysis tools of the reliability system work hand in hand with the tracking features of the work management system, allowing each to function at its maximum potential. By storing and processing data within the system best designed to handle this type of function, an integrated system is more streamlined and faster than the two systems used separately. The seamless interface between the two systems allows for ready exchange of data without degrading the performance of either application.

Vision for the Future

The vision for the future includes institutionalizing the philosophy and tools of the reliability focused maintenance program into the entire organization. In addition, a drive is in progress to improve the quality of the data continuously and work process supported by the system. This initiative is now driven not only by management, but also by the users who see the benefits of the system. More extensive goals include a significant reduction in the cost and impact of incidents, improved equipment up time, and availability and standardized best practices across all company sites.

Lessons Learned

Many lessons were learned as a result of this innovative response to the RFMS corporate initiative. Among these are that corporate initiatives do spawn real business change, especially if buy-in can be generated at all levels of a project. Similarly, senior management sponsorship is critical to effective business change.

Another lesson learned is that there is significant benefit in focusing on the reliability and availability of equipment when calculating the bottom line. From a problem-solving standpoint, industry has begun to learn that commercial off-the-shelf systems can solve complex business problems and processes, and that the strength of an integrated "best of breed" solution is greater that the sum of its parts.

As with any extensive and visionary changes, business change is hard work, but rewarding. Groups of people begin to communicate

that have rarely worked together before, and discover that their goals are common and needs are universal. People at every stage of the process are empowered to strive toward a level of independence and pride that results in a significant culture change—a desire to "work smarter," to use the tools that they have been given because they have seen real results. People begin to see the future of the industry and realize that they have been given a chance to control and shape that future for the better.